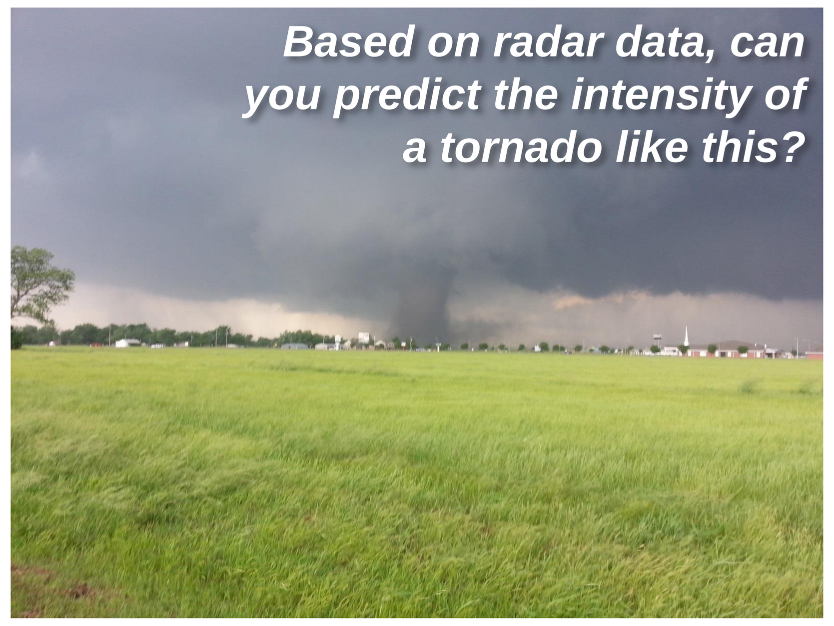

Correlation of Tornado Intensity with Dual-Polarization Radar Information

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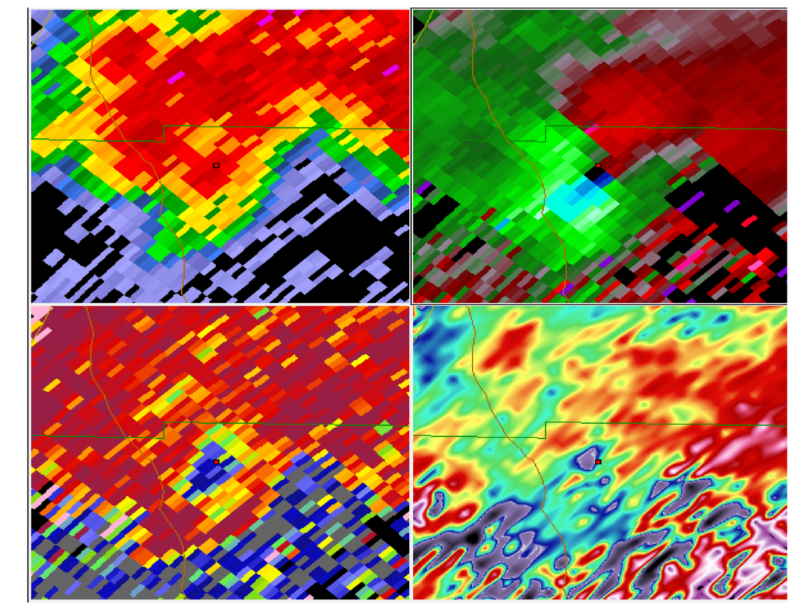
Steven E. Nelson – NOAA/NWS Atlanta/Peachtree City, GA



Motivation

Finding #2b of the NWS Service Assessment following the Joplin, MO tornado in 2011 states that "*The majority of surveyed Joplin residents* ***did not immediately go to shelter*** *upon hearing the initial warning…Instead,* ***most chose to further clarify*** *and assess their risk by waiting for, actively seeking, and filtering* ***additional information***." Our research seeks to develop relationships between tornado debris signature (TDS) characteristics and the intensity/size of a tornado using radar data.

Background

Tornado Debris Signature (TDS)

1. Identify a valid circulation (V)
2. Low correlation coefficient (CC < 0.85) ***collocated*** with circulation which indicates non-meteorological scatters such as debris.
3. Sufficient reflectivity (>35 dBZ) ***collocated*** with # 1 & 2 (Z)
4. Lowering of differential reflectivity (ZDR) near 0 indicative of spherical objects such as tumbling debris.

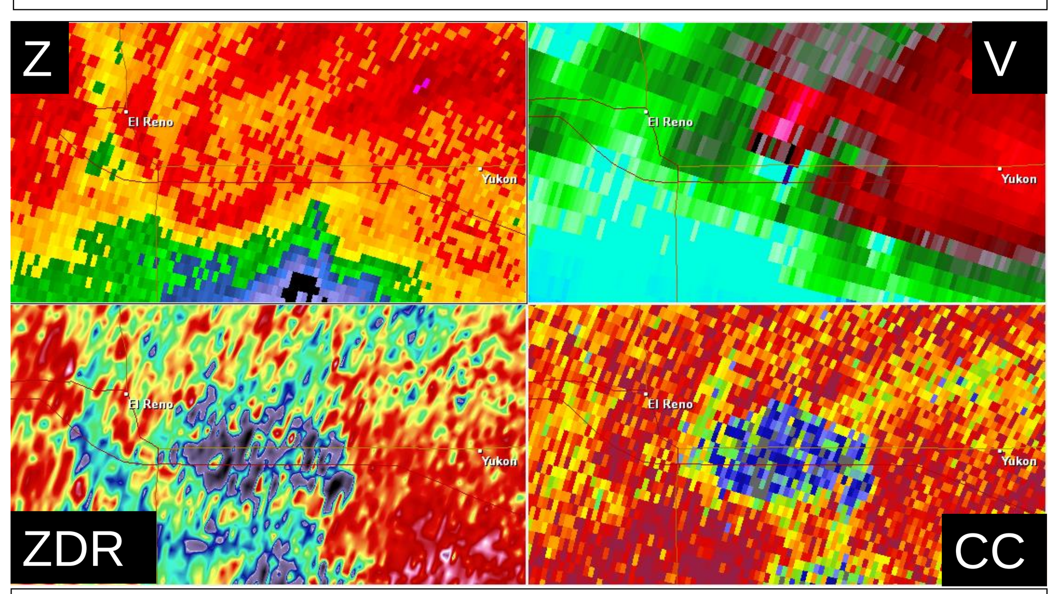


Figure 1: EF-3 tornado that hit El Reno, OK on 31 May 2013

Hypotheses

Which characteristics of a tornado debris signature will help meteorologists identify tornado intensity or size?

Hypothesis 1: The **minimum CC value** is not directly related to tornado intensity.

Hypothesis 2: Tornado intensity can be estimated in real time by determining the **maximum TDS height** using radar data.

Hypothesis 3: The **diameter of a TDS** is not directly related to the diameter of the tornado in the later stages of its life.

Data and Methodology

154 tornado cases were investigated from 4 August 2013 to 31 May 2014.
- Tornado cases were limited to significant tornadoes (EF-2 or greater) in the interest of time.

For each of the 154 events, these procedures were completed:
- Retrieved SPC Storm Data
- Determined closest radar site and distance from radar
- Downloaded WSR-88D Level II radar data
- Analyzed for presence of TDS with GR Level II Analyst (GR2Analyst)

For the cases in which a TDS was identified, the following data were collected:
- Maximum TDS height and diameter
- Centroid latitude and longitude
- Minimum CC
- Rotational velocity
- Storm mode

This research was added to a TDS database previously created by Chad Entremont (NWS JAN) and Chris Schultz (University of Alabama-Huntsville).
- The database included 142 TDS cases between 10 May 2010 and 29 September 2013.

For all TDS cases, SPC's Storm Data and NWS storm surveys accessed via the Damage Assessment Toolkit (DAT) were utilized to record:
- Max rated wind speed
- Starting latitude and longitude
- Path length and width

A total of 175 tornadoes with a complete documentation of TDS information were recorded between the two studies.
- Of those cases, 70 were EF-0 or EF-1 and were excluded from analysis

EF-2	EF-3	EF-4	EF-5	TOTAL
59	32	12	2	**105**

Figure 2: Final breakdown of TDS tornado intensities used in analysis.

Hypothesis 1 Methodology

Using GR2Analyst, scroll over CC pixels within the TDS to determine the lowest value.

Hypothesis 2 Methodology

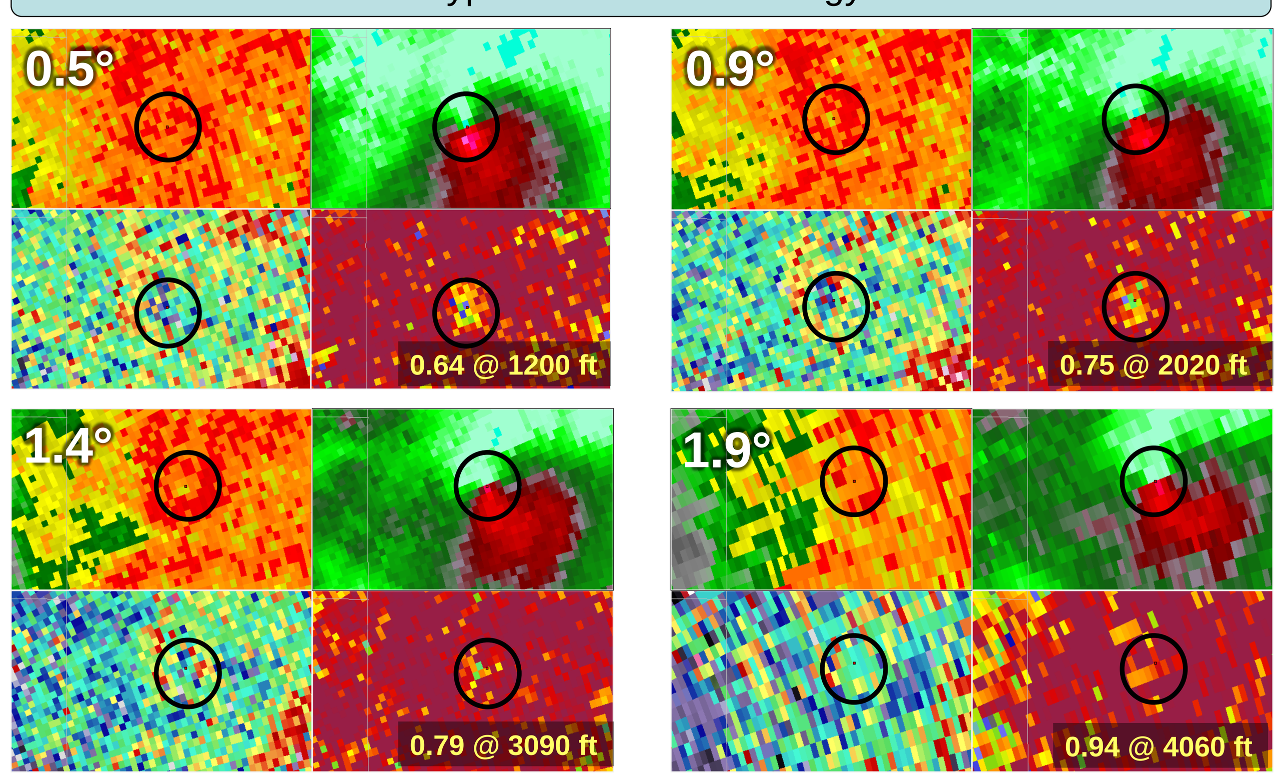


Figure 3: Determination of maximum TDS height using GR2Analyst data. TDS exists when all four criteria from above are met. Main indicator is minimum CC value which must be less than 0.85. The 1.9° scan indicates a minimum of 0.94 so the maximum TDS height occurs at 3090 ft. (*Images courtesy Chad Entremont, NWS JAN*)

Hypothesis 3 Methodology

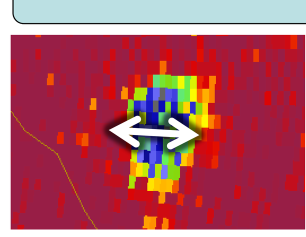


Figure 4: Determination of TDS diameter using GR2Analyst Data. Use Cross-Section tool to measure cross section of CC minimum along the radial perpendicular to the radar to determine the width.

Results

Hypothesis 1: Minimum CC Value

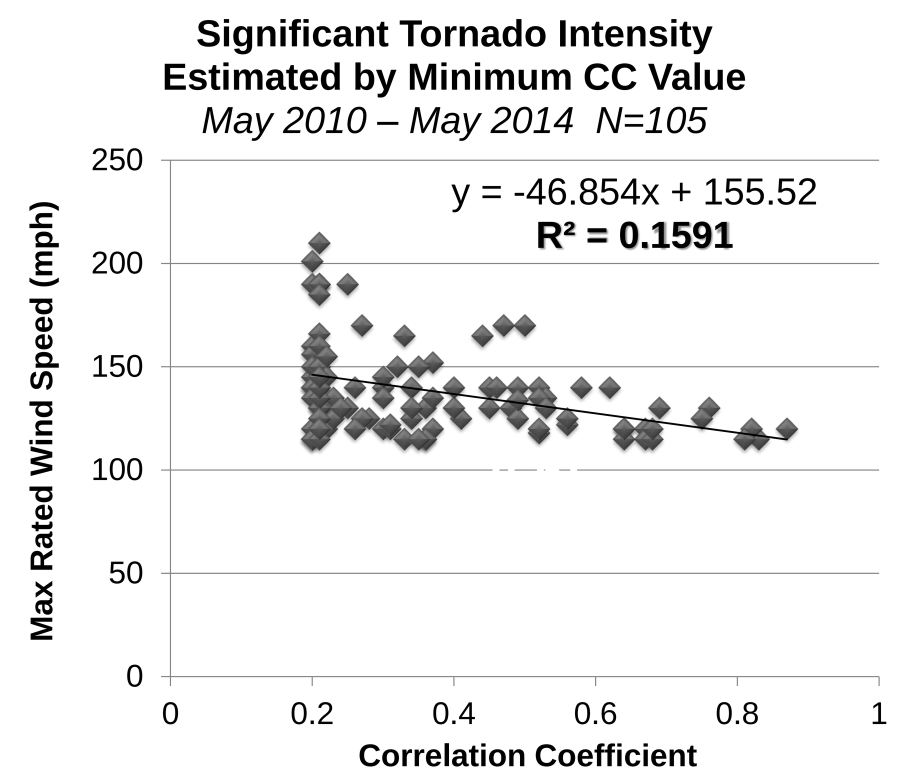


Figure 5: Correlation of minimum correlation coefficient (CC) with max rated wind speed.

Hypothesis 2: Maximum TDS Height

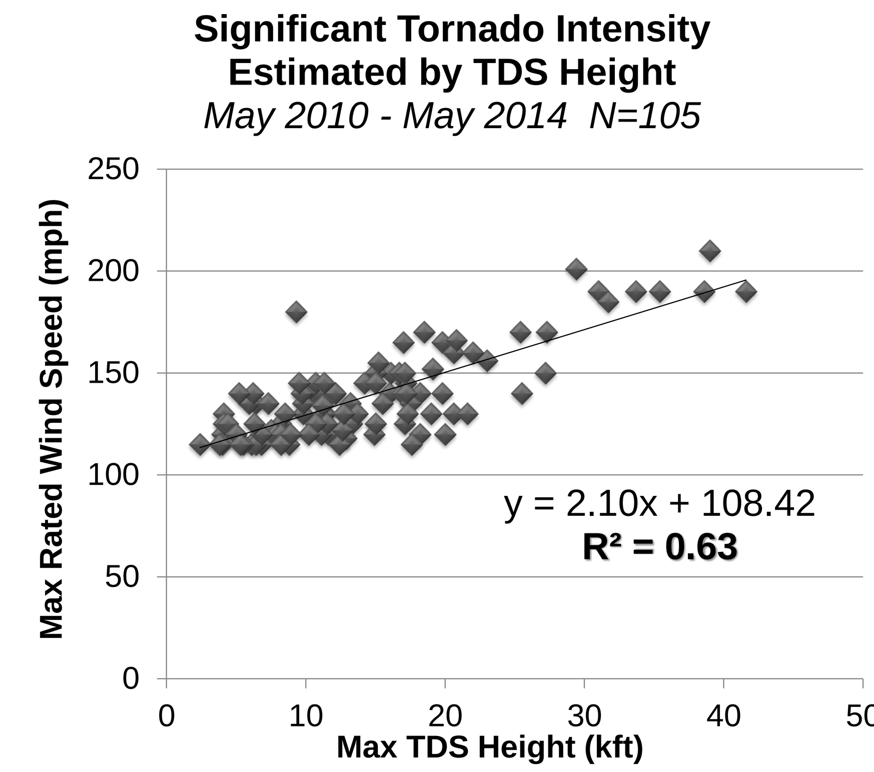


Figure 6: Correlation of maximum TDS height with max rated wind speed.

Hypothesis 3: TDS Diameter

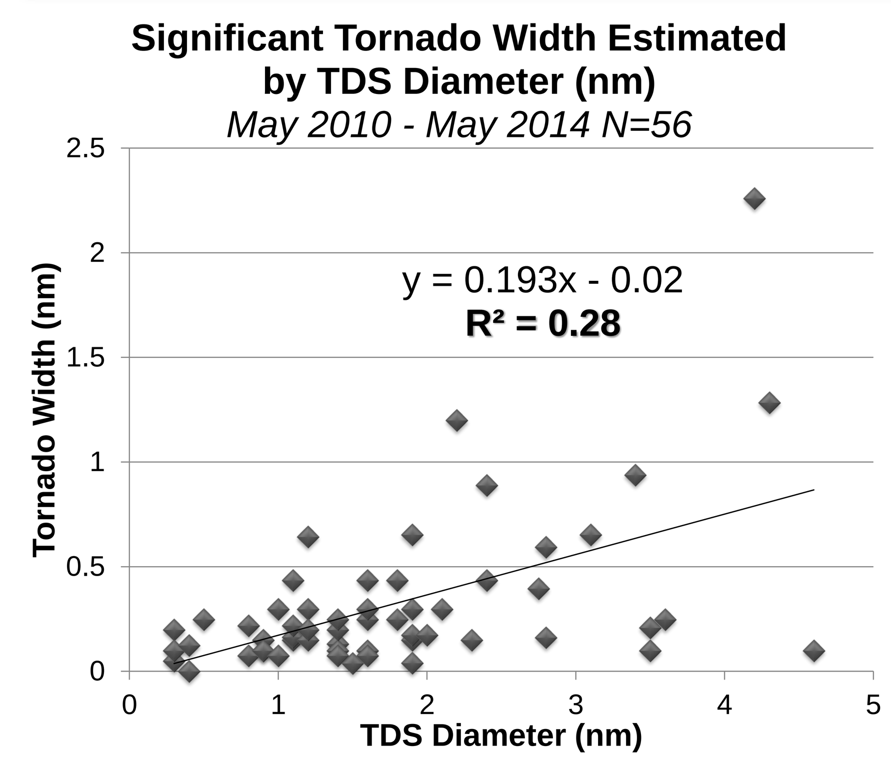


Figure 7: Correlation of TDS diameter with tornado width. *Note:* Cases include Moore, OK EF-5 20 May 2013, El Reno, OK EF-3 on 31 May 2013, and 08/2013-05/2014 from most recent TDS analyses.

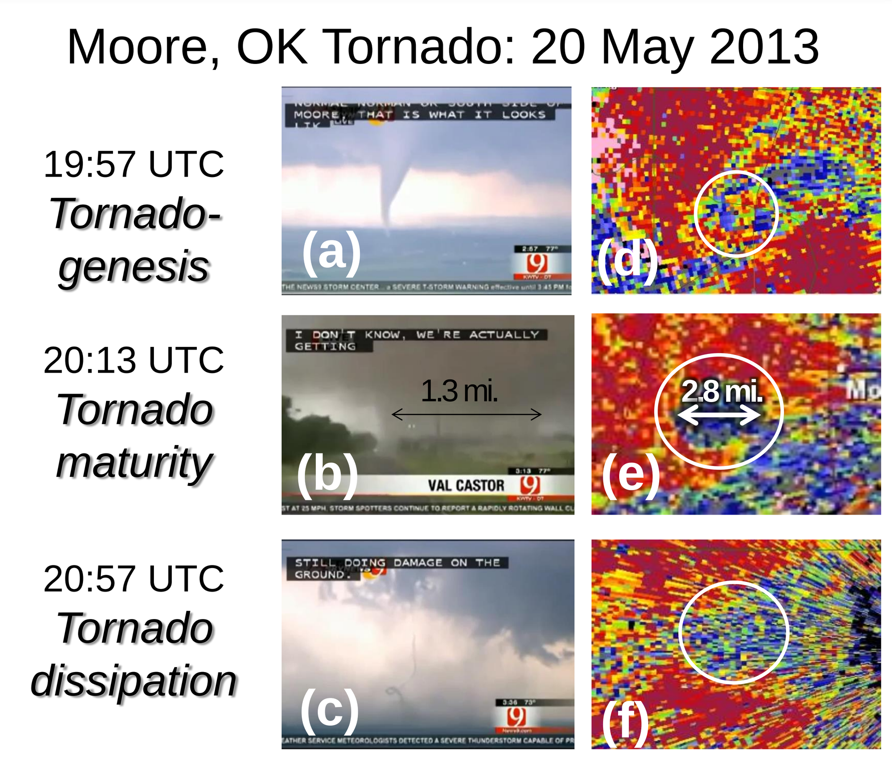


Figure 8: (a)-(c) live shots from News9 in Oklahoma City (d)-(f) CC indicating TDS diameter. TDS width doesn't represent tornado width in maturity or dissipation stages.

Application at Peachtree City, GA NWS Office

	Tornado Warning	Tornado Emergency	
	Enhanced Wording	Consider	Strongly Consider
Rotational Velocity	50-80 kts	70-80 kts	≥ 80 kts
TDS	8-20 kft	15-20 kft	≥ 20 kft

Figure 9: Tornado warning guidance used at the National Weather Service in Peachtree City, GA.

```
BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE PEACHTREE CITY GA
814 PM EST FRI MAR 2 2012

THE NATIONAL WEATHER SERVICE IN PEACHTREE CITY HAS ISSUED A

* TORNADO WARNING FOR...
  NORTHERN HARALSON COUNTY IN NORTHWEST GEORGIA
  NORTHWESTERN PAULDING COUNTY IN NORTHWEST GEORGIA
  SOUTHERN POLK COUNTY IN NORTHWEST GEORGIA

* UNTIL 900 PM EST

* AT 809 PM EST...DOPPLER RADAR CONFIRMED A TORNADO 17 MILES
SOUTHWEST OF ROCKMART...MOVING EAST AT 40 MPH.
```

Conclusions

- Recent literature has noted a relationship between TDS height and tornado intensity based on the Enhanced Fujita (EF) scale. (Schultz et al. 2012)
- No previous research on wind speed correlations
- 105 EF-2 or stronger tornadoes exhibiting a TDS were analyzed

Which characteristics of a tornado debris signature will help meteorologists identify tornado intensity size?
- Minimum CC value – NO
- Maximum TDS height – YES

Does the diameter of a TDS resemble the width of the tornado on the ground?
- NO – Especially not in later stages of life cycle

Future Direction

Short-term goals:
- Examine EF-0 and EF-1 cases
- Continue updating TDS database
- Senior thesis research at The Ohio State University

Long-term goals:
- Collaborate with SPC to create TDS database supplemental to Storm Data
  - Facilitate research relating parameters such as Significant Tornado Parameter, CAPE, etc. to TDS characteristics
- Investigation of land use/vegetation type using ArcGIS

References

Schultz et al., 2012: Dual-Polarization Tornadic Debris Signatures Part I: Examples and Utility in an Operational Setting. *Electronic J. Operational Meteor.*, 13 (9), 120–137.

Schultz et al., 2012: Dual-Polarization Tornadic Debris Signatures Part II: Comparisons and caveats. *Electronic J. Operational Meteor.*, 13 (10), 138−150.

Entremont, C., 2013: Relationship Between Tornado Debris Signature (TDS) Height and Tornado Intensity. Southeast Severe Storms Symposium, Mississippi State University.

Acknowledgements

- Steven Nelson, SOO, NWS FFC, project mentor
- Keith Stellman, MIC, and entire staff at NWS FFC
- Chad Entremont (NWS JAN) and Chris Schultz (UAH) for work compiling TDS database from 2010-2013 cases
- NOAA Office of Education and the Student Scholarship Team from the Hollings Scholarship Program
- Ariel Cohen (SPC forecaster) for his assistance with poster design and creation

Questions or Comments?

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